PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re:	Barocela	Confirmation No.:	1685
Appl No.:	10/811,735	Group Art Unit:	3644
Filed:	03/29/2004	Examiner:	Dinh, Tien Quang
For:	HIGH SPEED MISSILE WING AND ASSOCIATED METHOD		

Docket No.: 038190/274032
Customer No.: 00826

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

DECLARATION UNDER 37 C.F.R. § 1.131

Sir:

I, Edward Barocela, hereby declare and state that:

1. I am the inventor of the claimed invention of the above-identified U.S. Patent Application Serial No. 10/811,735.

2. I have read and understand U.S. Patent No. 6,923,404 to Liu et al. ("Liu"), which was filed January 10, 2003 and issued August 2, 2005, and U.S. Patent No. 6,601,795 to Chen ("Chen"), which was filed August 23, 2002 and issued August 5, 2003. Liu and Chen were relied upon by the Examiner in the final Official Action mailed November 15, 2006 as disclosing or suggesting independent Claims 1 and 16 of the above-referenced application. This Declaration is filed to establish actual reduction to practice prior to the filing date of Liu and prior to the issue date of Chen.

3. Prior to January 10, 2003, the filing date of Liu, and August 5, 2003, the issue date of Chen, I actually reduced the claimed invention to practice. In particular, I constructed a

prototype that worked for its intended purpose, as described below, thereby reducing to practice my invention as described and claimed in the subject application, which is generally directed to a missile and missile system. In support of this statement, I have attached Exhibits 1 and 2. Although the dates of Exhibits 1 and 2 are not shown, these exhibits are dated prior to both January 10, 2003 and August 5, 2003 (*See MPEP § 715.07: Establishment of Dates*).

4. In support of the foregoing statement regarding actual reduction to practice, I hereby submit the best available copy of the following documents:

a. Exhibit 1 – Presentation illustrating the internal components and design specifications of a missile according to one embodiment of the claimed invention.

b. Exhibit 2 – Presentation describing and illustrating experimental results of a wind tunnel test using a scaled representative model of a missile having a pivotable oblique wing.

5. Exhibits 1 and 2 provide support that I reduced to practice the missile and missile system of the claimed invention that generally includes an oblique wing that is pivotable from a position substantially aligned with a fuselage member to a predetermined sweep angle at transonic speed during flight.

6. More specifically, Exhibits 1 and 2 disclose a missile and a missile system of at least independent Claims 1 and 16 of the present application. In this regard, Exhibit 1 discloses a missile including a fuselage member configured to carry an engine. In addition, Exhibit 1 discloses a wing actuator carried by the fuselage member and an oblique wing member pivotally connected to the fuselage member. Exhibit 1 further discloses that the wing member is pivotable by the wing actuator from a position substantially aligned with the fuselage member to a predetermined sweep angle of less than 90 degrees at transonic speed during flight. Furthermore, Exhibit 1 discloses a missile releasably attached to an aircraft.

7. Exhibit 2 discloses that the claimed invention was reduced to practice. Namely,

Exhibit 2 discloses that a scaled representative model of a missile having a pivotable oblique wing according to one embodiment of the claimed invention was tested in a wind tunnel. Exhibit 2 also discloses test results of the experiment, including L/D at various angles of attack and Mach numbers, as well as a comparison of the drag coefficient at various Mach numbers for both conventional and oblique wings.

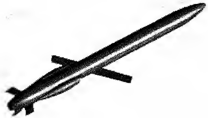
8. All of the work I did in connection with this invention was carried out in the United States.

9. I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application of any patent issued thereon.

Edward Barocela

Edward Barocela

EXHIBIT 1



BOEING

Air Vehicle Configuration

Ed Barocela

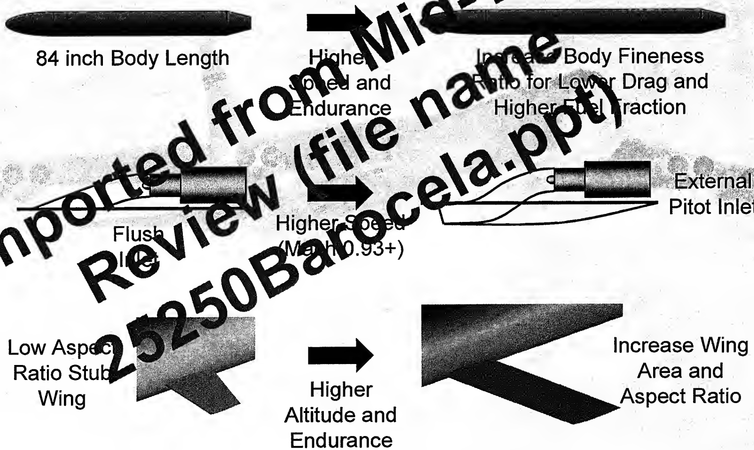
BOEING

IRD Requirements

Requirement	Threshold	Objective
Operating Airspeeds	up to 0.93 M @ 35 kft	up to 0.95 M @ 40 kft
Endurance	45 min @ 35 kft	60 min @ 35 kft
Loiter (Jammer)	30 min On-Station	40 min On-Station
Min. Rate of Climb	1500 fpm @ 25 kft	*Not Specified*
Turn Maneuverability	2 G's up to 19 kft	3 G's up 25 kft

BOEING

Meeting New Requirements



1st ALVIN Concept

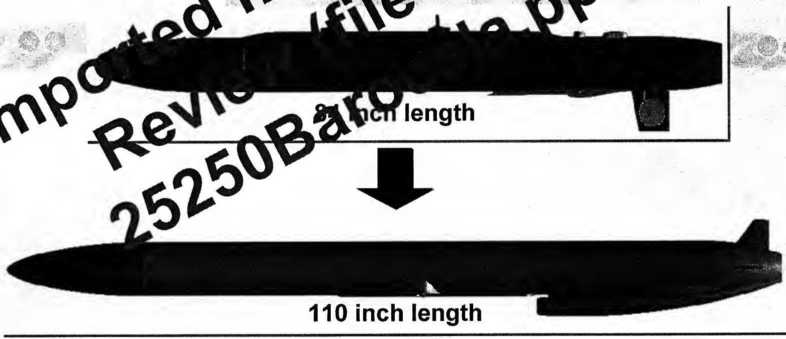
- 7 Inch Diameter Circular Body
- 110 Inch Total Length
- Low Mounted Wing
  - Wing Fold Mechanism Outside of Fuel Tank
- High Aspect Ratio (AR = 8)
- External Pitot Inlet in Ventral Position

BOEING

Increase Fuel Fraction

"Grow" the Missile

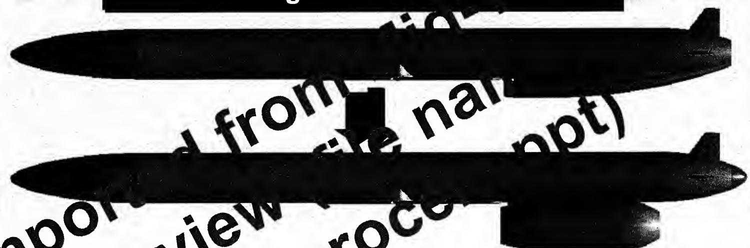
- Current MALD is volume-limited compared to new IRD requirements
  - Fuel tank occupies largest fraction of fuselage length, yet
  - Fuel Fraction ~20%



BOEING

Increase Fuel Fraction

Increase Fuel Fraction



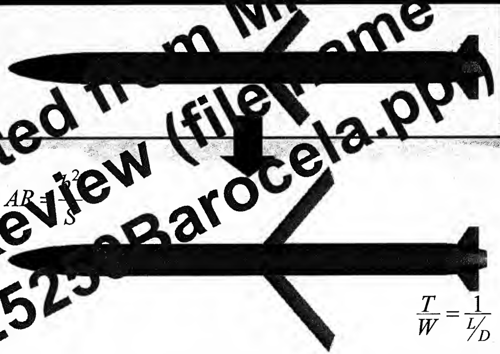
Raytheon *Streaker*

- Frees up fuselage internal volume for fuel
- External engine installations have been used on high speed drones (Mach No. > 0.9)

BOEING

Increase Aerodynamic Efficiency

Increase Wing Aspect Ratio



$$AR = \frac{b^2}{S}$$

$$\frac{T}{W} = \frac{1}{L/D}$$

- Increase lift-to-drag ratio (L/D)
- Probably dictates high or low wing

BOEING

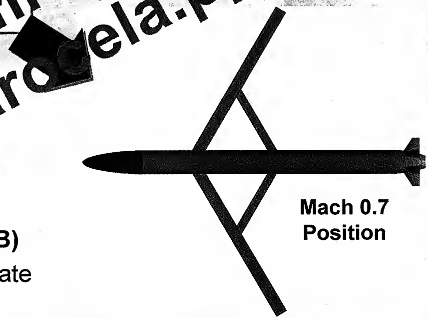
Alternate Wing: Option 1

Dual Position Wing

- First position used for high speed dash (lowest drag)
- Second position used for long endurance cruise and loiter (highest L/D)

Small Diameter Bomb (SDB)

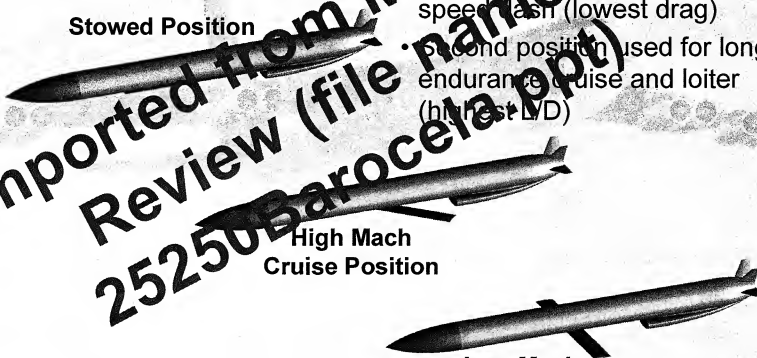
Folding wing design is candidate for MALD



Alternate Wing: Option 2

Oblique Wing

- First position used for high speed dash (lowest drag)
- Second position used for long endurance cruise and loiter (highest L/D)



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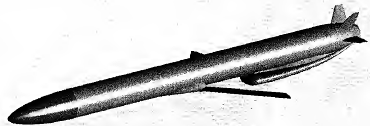
Alternate Wing: Option 3

Diamond Wing

- Innovative wing shape tested for Sensorcraft
- Aerodynamically equivalent to high aspect ratio wing
- Span can be reduced to eliminate need to fold wing
- More wing sections available for antenna placement

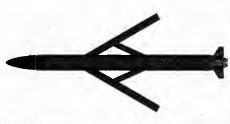
Alternative Configurations



ALV-1		Circular cross section body AR 8 wing
ALV-2		Triangular cross section body AR 8 wing
ALV-3		Square cross section body AR 8 wing

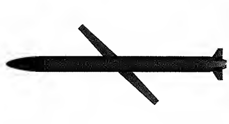
Alternative Configurations (cont.)

ALV-4



Circular cross section body
Diamondback wing

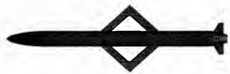
ALV-5



Circular cross section body
Oblique wing

Alternative Configurations (cont.)

ALV-6



- Circular cross section body
- Joined wing

ALV-7

- Circular cross section body
- AR 8 wing
- External engine nacelle

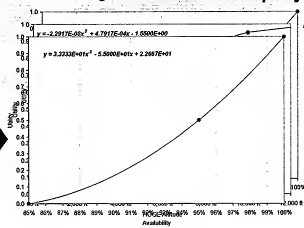
Trade Study Methodology

Total Score = $\sum W_i U_i$

Candidate Configuration Data

- *Cruise Speed*
- *Endurance*
- *Maneuverability*
- *Weight*
- *Fuel Fraction*
- *Technical Risk*

Utility Functions, u_i



Weighting Factors, w_i

iSIGHT

- *Parameter Sensitivity*
- *Candidate Scores & Rankings*

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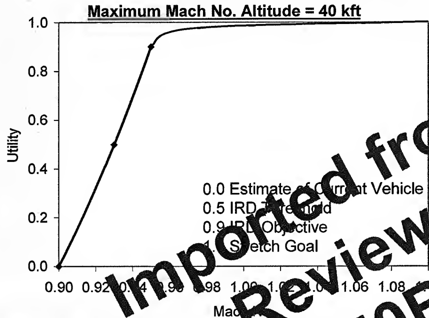
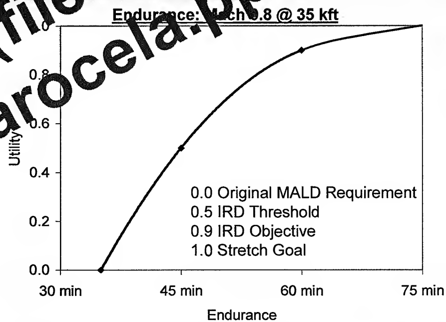
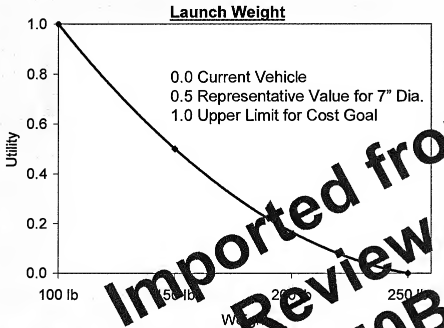
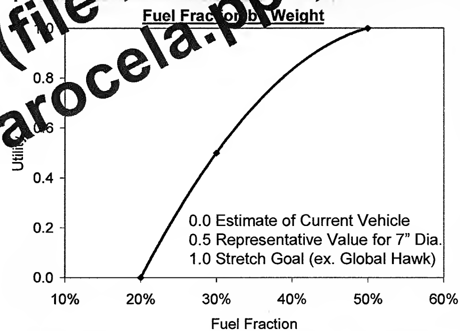
ALVIN Utility Functions



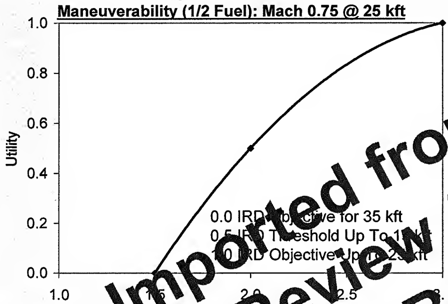


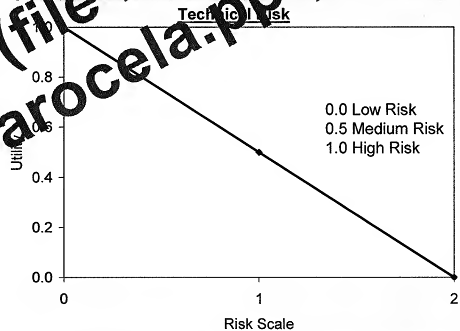
ALVIN Utility Functions

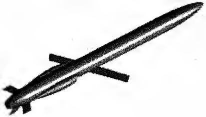




ALVIN Utility Functions







BOEING

Technology Item: Unconventional Wing

Oblique Wing, Diamondback Wing, Joined Wing

Risk:

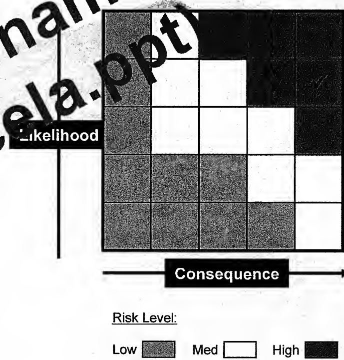
Unconventional wing performance will fall short of predictions

Consequences:

Performance shortfalls (speed, endurance)

Mitigation:

Wind tunnel measurements to validate aero code predictions. Carry alternative configuration through preliminary design phase as fall-back.



BOEING

Technology Item: Future Variant Evolution

Choice of Engine and Missile Diameter

Risk:

Future variants will require different engine installations to meet increased performance, payload and power requirements

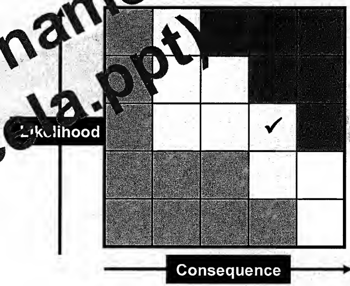
Consequences:

Future variant designs will diverge from MALD baseline; will require significant re-design

Mitigation:

Conduct studies of future variants early.

Consider external or semi-recessed nacelle.



Risk Level:

Low Med High

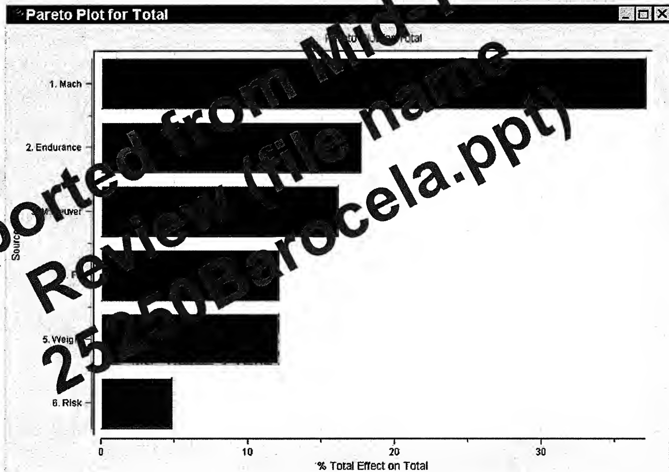
BOEING

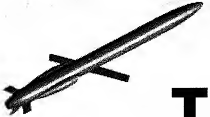
Trade Study Results

Candidate	Mach	Endurance	Maneuver	Weight	FF	Risk
ALV-1	0.99	55.3 min	2.7 g's	153 lb	27%	Medium
ALV-2	0.93	54.2 min	2.5 g's	161 lb	27%	Medium
ALV-3	0.90	59.6 min	2.4 g's	170 lb	29%	Medium
ALV-4	0.94	53.6 min	2.6 g's	164 lb	25%	High
ALV-5	1.00	59.1 min	2.7 g's	153 lb	27%	High
ALV-6	0.99	55.4 min	2.7 g's	152 lb	27%	High
ALV-7	0.97	67.6 min	2.6 g's	165 lb	31%	Low

BOEING

iSIGHT Analysis: Utility Function Sensitivities





BOEING

Trade Study Scores*

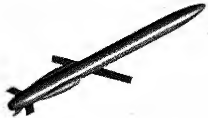
Candidate	Total	Rank
ALV-7	4.69	1
ALV-1	4.04	2
ALV-5	3.62	3
ALV-6	3.56	4
ALV-2	3.40	5
ALV-4	3.02	6
ALV-3	2.95	7

Weight Factors = 1

Candidate	Total	Rank
ALV-7	4.91	1
ALV-1	4.69	2
ALV-5	4.65	3
ALV-6	4.57	4
ALV-4	3.72	5
ALV-2	3.48	6
ALV-3	2.42	7

Pareto Weight Factors

Maximum Possible Score = 6

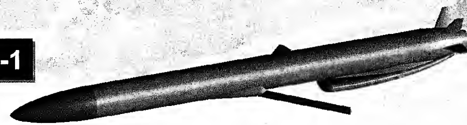


Preferred Concept Candidates

ALV-7

External Nacelle

ALV-1



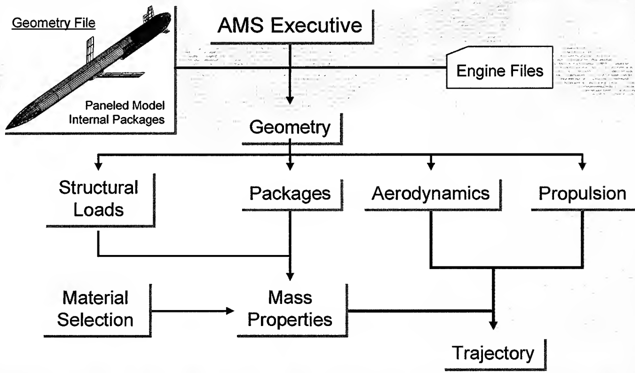
Benchmark Configuration

ALV-5

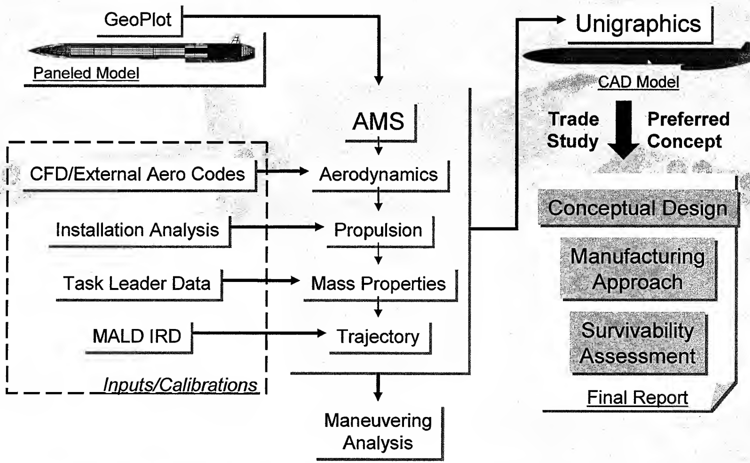
Oblique Wing
(may require bifurcated inlet)

Automated Missile Synthesis (AMS)

- Workstation-based synthesis tool
- Methodologies used in related codes (LODST, AVIS)



Configuration Development

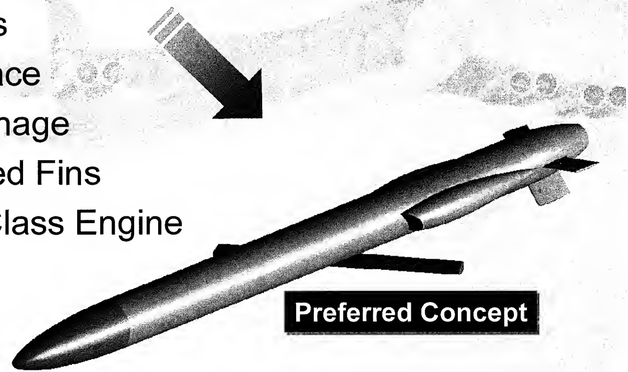


ALVIN Preferred Concept

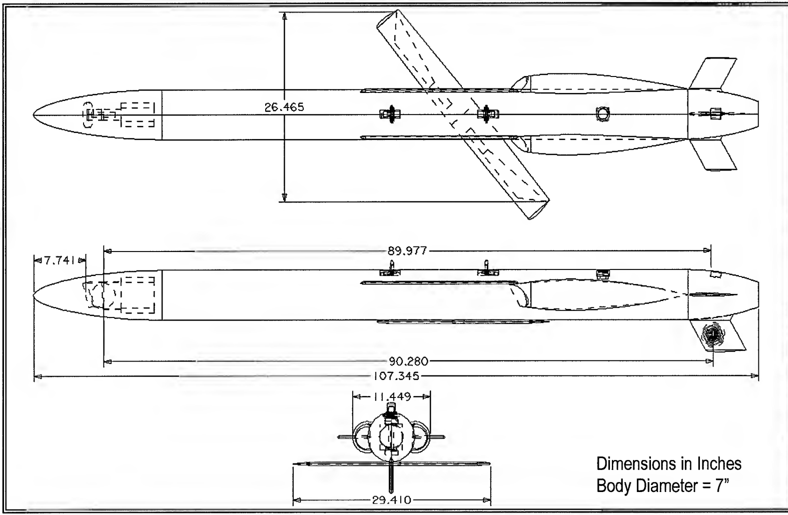
- Preferred Concept Design
- Preferred Concept Performance
- Manufacturing Approach
- Risk Mitigation

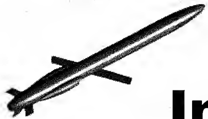
Design Modifications

- Bifurcated Inlets
- Scarfed Inlet Face
- "Y-Tail" Empennage
- Planform-Aligned Fins
- 100 lb_f Thrust Class Engine

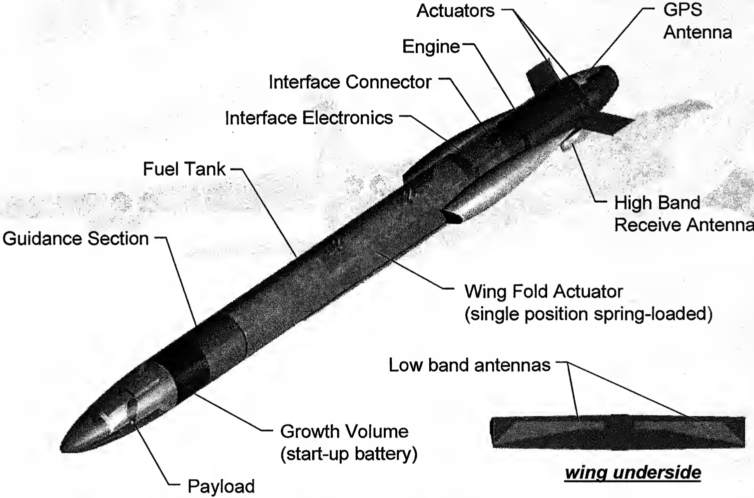


Preferred Concept





Internal Components



wing underside

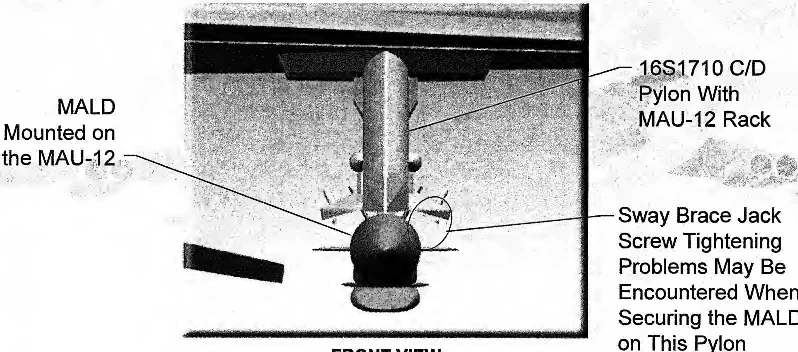
BOEING

Weight Statement

ITEM	EQUIPMENT	STRUCTURE	FUEL	TOTAL
Body		26.8 lb		26.8 lb
Wing		2.0 lb		2.0 lb
Horizontal Tail		0.6 lb		0.6 lb
Vertical Tail		2.3 lb		2.3 lb
Wing Fold		0.8 lb		0.8 lb
Bifurcated Inlets		4.4 lb		4.4 lb
Payload	10.0 lb	2.4 lb		12.4 lb
Avionics	15.0 lb	3.1 lb		18.1 lb
Fuel Tank	1.0 lb	6.9 lb	40.7 lb	48.5 lb
Miscellaneous	8.0 lb	2.1 lb		10.1 lb
Actuators	5.0 lb	1.5 lb		6.5 lb
Growth	2.0 lb	0.8 lb		2.8 lb
INLET	1.2 lb	0.6 lb		1.8 lb
ENGINE	26.8 lb	4.5 lb		31.3 lb
TOTALS	69.0 lb	58.9 lb	40.7 lb	168.6 lb

“Worst Case” with Heaviest Engine and Actuators

Bomb Rack Integration Issue



FRONT VIEW

This Front View Shows the MALD Mounted on the 16S1710 C/D Pylon/MAU-12 Station 3 Is Shown With Station 7 Being Identical

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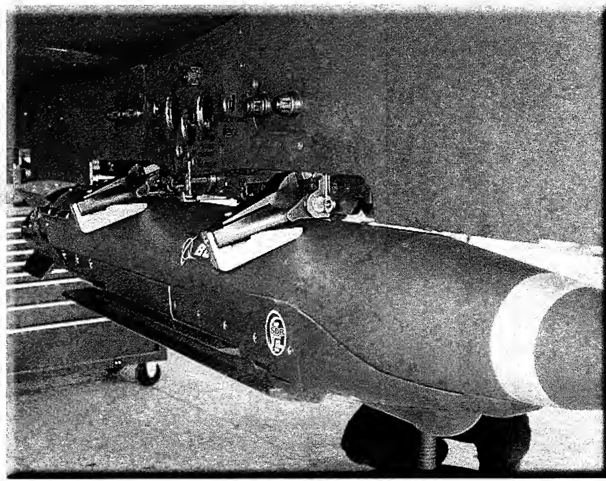
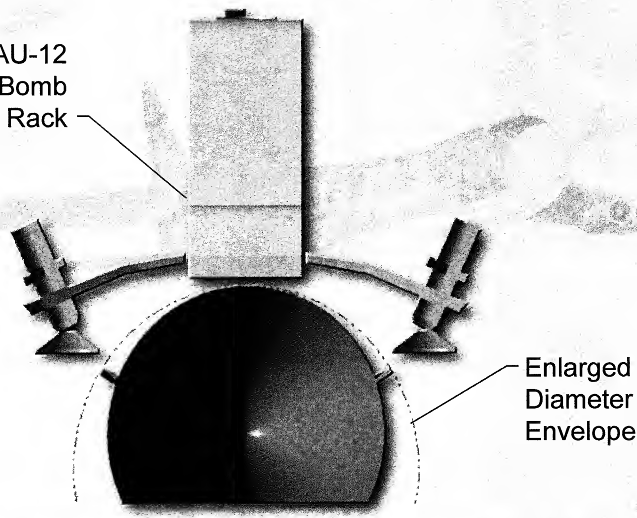
Small Diameter Bomb Sway Brace Extenders

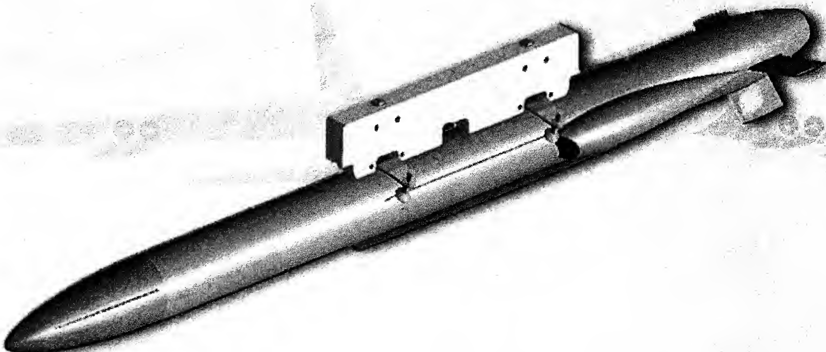


AIR LAUNCHED VEHICLE INVESTIGATION

Strake Definition

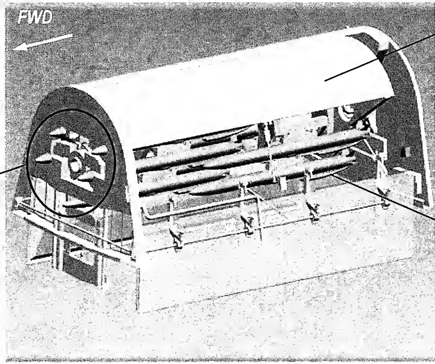


MAU-12 Attachment with Body Strake



B-1B Reduced Loadout

MALDS Mounted on Stations C11, C12, C21, C22 and C23 to the Bay FWD Bulkhead, Interference Detected



10 Station BRA

MALDS Mounted on All Stations of the BRA in the Aft Bay

AFT BAY SHOWN

This View Shows the MALDS Mounted on All Locations of the 10 Station BRA in the Aft Weapons Bay. The Aft Weapons Bay Was Used Because it Represents the Smallest Envelope, However, the Same Results Would Be Experienced in the Forward and Intermediate Weapons Bays. Aircraft Not Shown for Clarity.

F-15E Reduced Loadout

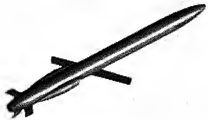
Station 5 MALD Has the Same Tail Fins to Pylon Interference Detected that Is Evident on stations 2, 8 and the CFT's

Configuration "A" and "B" Is shown in This Image With the Boeing MALD Concept Loaded Onto stations LC1, LC2 and LC3. Notice 2 Circled Areas Where There Is Some Major Interference Detected!

Loadout Improvement Options

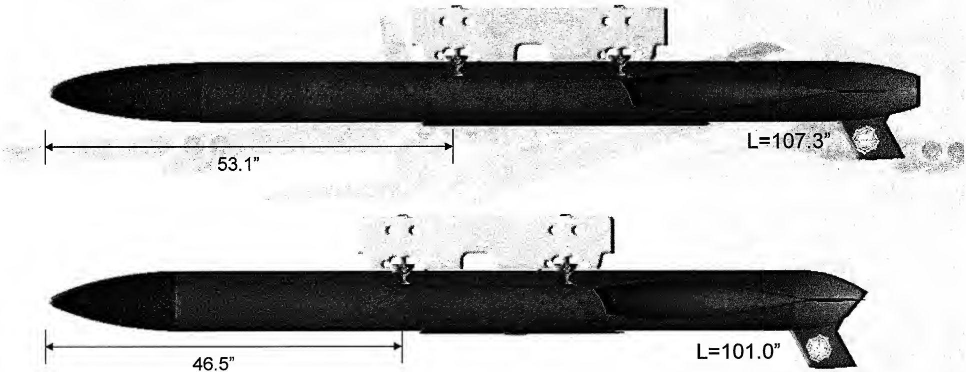
- Shorten Nose Cone
  - Replace Conic Ogive Profile With Sears-Haack Profile to Reduce Drag
- Choose Compact Engine to Shorten Boattail
  - Example: TJ-50M

NOTE: launch lugs may straddle CG by ± 3 inches



Shortened Missile

Original Nose-Lug Distance = 55.1”



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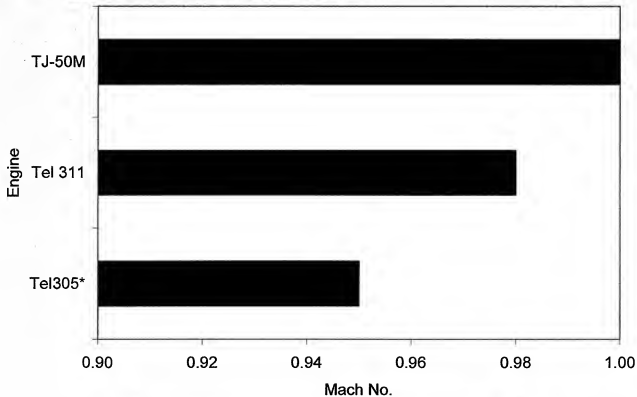
Air Vehicle

- Preferred Concept Design
- Preferred Concept Performance
- Manufacturing Approach
- Risk Mitigation

Vehicle Performance

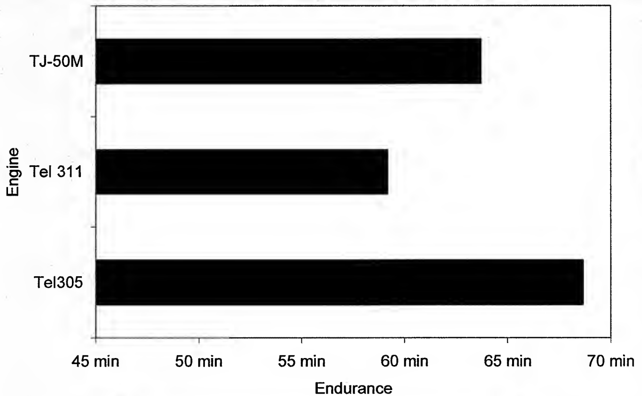
Maximum Operating Airspeed at 40,000 ft



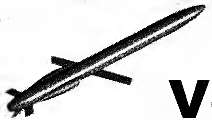
* maximum altitude = 35,000 ft

Performance (cont.)

Maximum Endurance at 35,000 ft



Operating Airspeed = Mach 0.8



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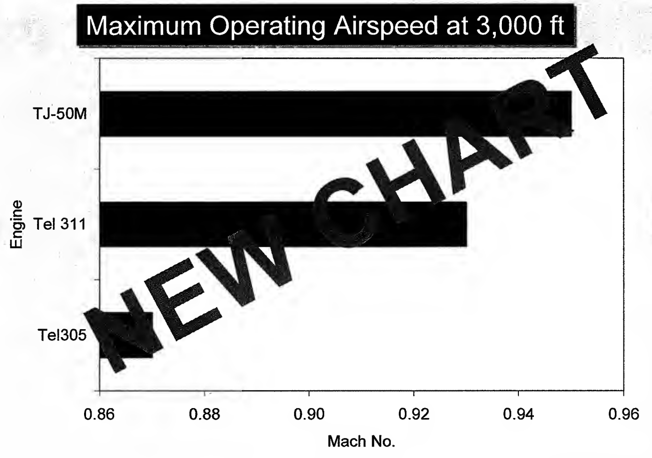
Vehicle Performance



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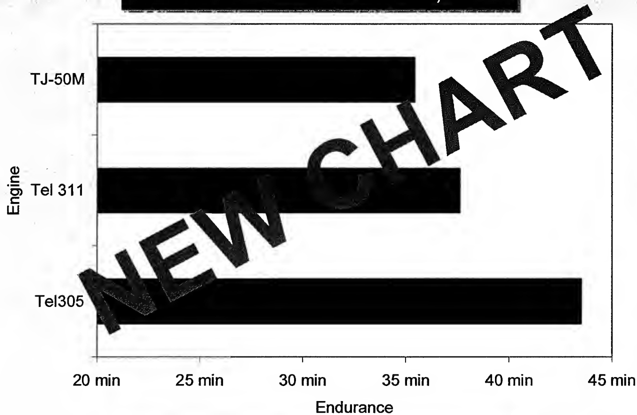
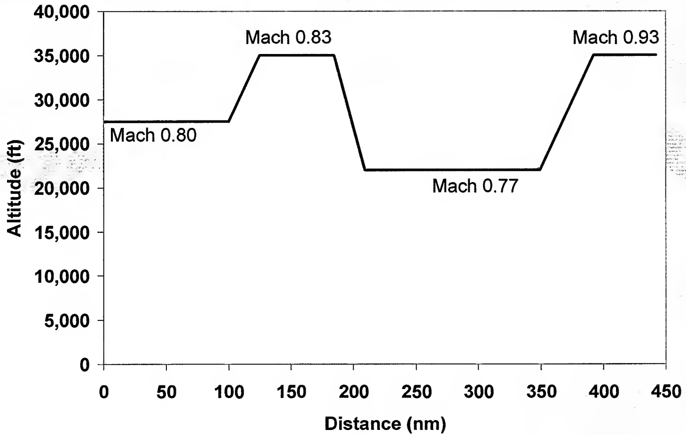
Performance (cont.)

Maximum Endurance at 3,000 ft

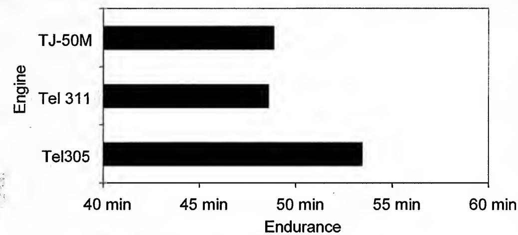


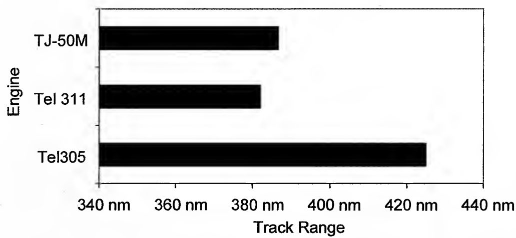
Operating Airspeed = Mach 0.55

Decoy Mission Profile

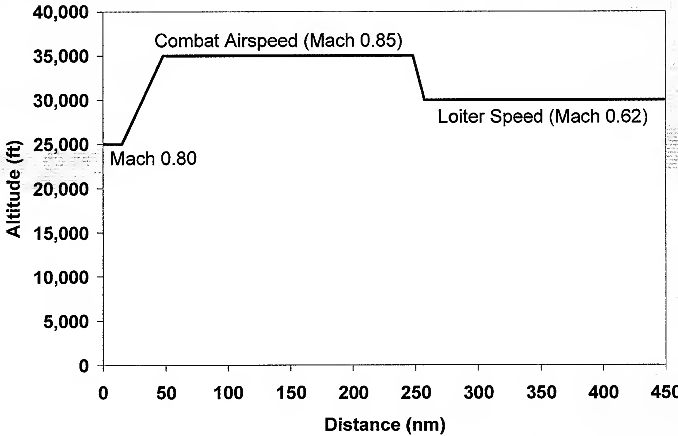


Decoy Reference Mission Performance





Jammer Mission Profile



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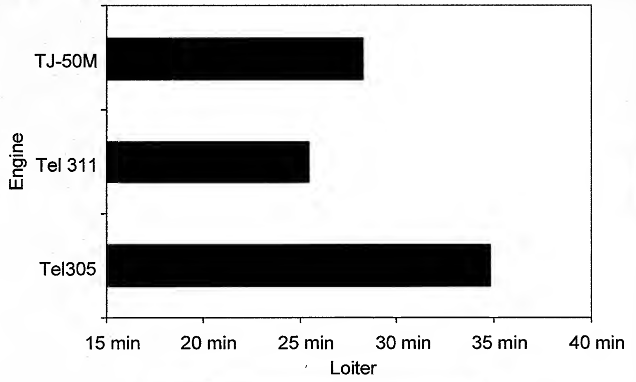
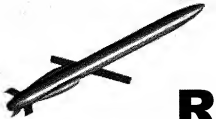
Jammer Mission Performance



<u>Optimum Loiter Speed</u>
Teledyne Engines: Mach 0.62
TJ-50M: Mach 0.65-0.70

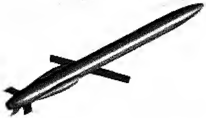


Radar Cross Section

- Analysis Performed on "All-metal" Representation of Missile
  - VHF, UHF, L, S, C, X and Ku Bands
  - 360º Sweep at Different Elevations
- Results Indicate That Design:
  - Will Meet Requirements of Primary Decoy Mission
  - Is Sufficiently Robust to Support Growth Missions

RCS (cont.)

- Several Design Features Will Degrade Radar Signature
  - Reflections From SAS Payload Through Radar-transparent Nose
  - Details of Engine Inlet Boundary Layer Diverter (Internal or External)
  - Body Strake



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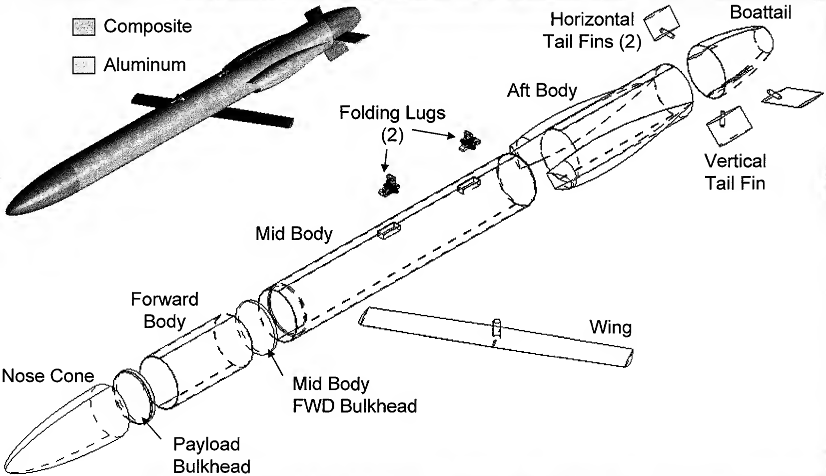
Air Vehicle

- Preferred Concept Design
- Preferred Concept Performance
- Manufacturing Approach
- Risk Mitigation

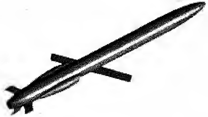
Airframe Structure

11 Structural Airframe Components



Materials and Processes

Component	Material	Process
Nose Cone	Glass Fiber Filled Ultem	Injection Molding
Payload Bulkhead	Aluminum	High Speed Machining
Forward Body	Aluminum	Extruded Tube
Mid Body Forward Bulkhead	Aluminum	Casting
Mid Body	Aluminum	Casting
Aft Body	Aluminum	Casting
Boattail	Glass Vinylester	Compression Molding
Wing	Glass/Epoxy with Spindle Insert	Resin Transfer Molding
Vertical Tail Fin	Glass/Epoxy with Root Fitting	Resin Transfer Molding
Horizontal Tail Fins	Glass Fiber Filled Ultem with Spindle Insert	Injection Molding
Folding Lugs	Steel	Machining



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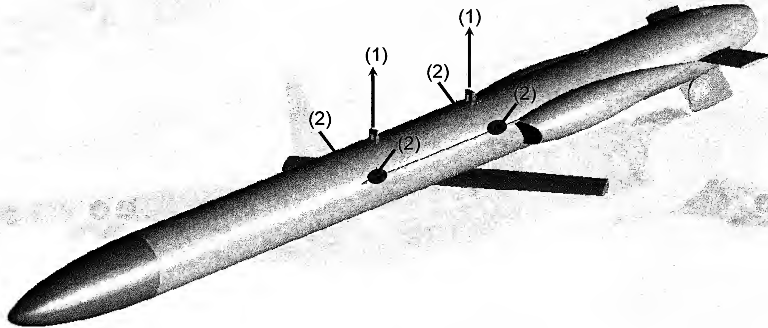
Component Sizing Conditions

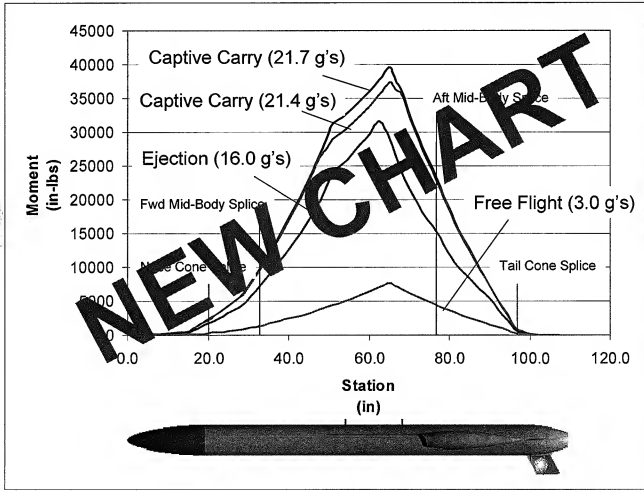
Component	Captive Carry	Ejection	Free Flight	Internal Pressure
Nose Cone	■	■	■	
Payload Bulkhead	■	■	■	
Forward Body	■	■	■	
Mid Body Forward Bulkhead	■	■	■	■
Mid Body	■	■	■	■
Aft Body	■	■	■	
Boattail	■	■	■	
Wing			■	
Vertical Tail Fin			■	
Horizontal Tail Fins			■	
Folding Lugs	■			

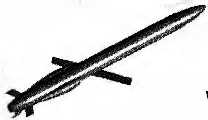
Preliminary Design Loads



(1) Maximum Hook Tension (2 places) = 2,000 lb_f
(2) Maximum Sway Brace Compression (4 places) = 2,000 lb_f
(3) Maximum Captive Carry Acceleration = 13 g's vertical, 22 g's total
(4) Ejection Acceleration = 16 g's
(5) Maximum Flight Acceleration = 3 g's

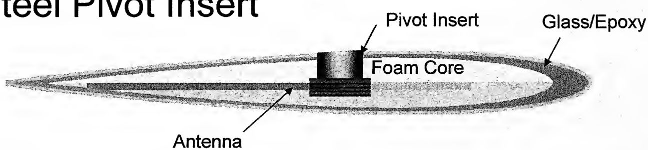
Preliminary Body Bending Moments



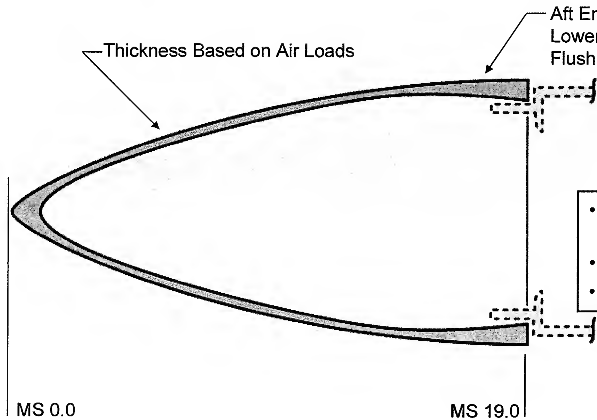


Wing Construction

- Resin Transfer Molding Process Will Incorporate Low Band Dipole Antenna
- Materials
  - Glass/epoxy Skins
  - Foam Core
  - Steel Pivot Insert

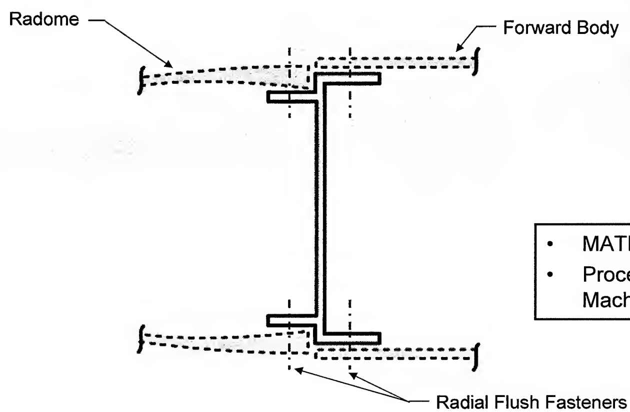


Nose Cone Construction



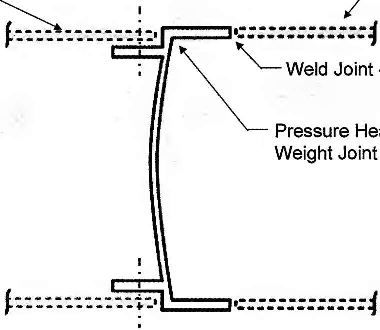
- No Re-entrant IML for Minimal Tooling
- MATL - Glass Filled Ultem
- Process - Injection Molding

Payload Bulkhead

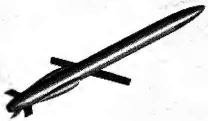


- MATL - Aluminum
- Process - High Speed Machining

Midbody Forward Bulkhead



- MATL - Aluminum
- Process - Casting



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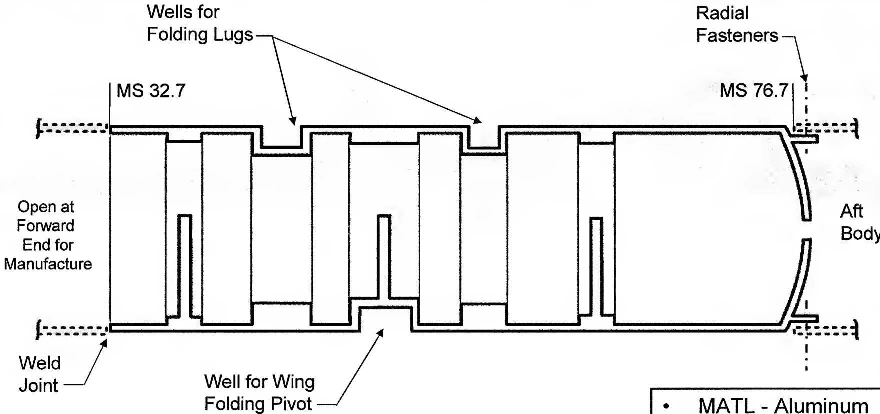
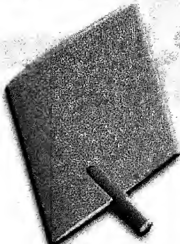
MALD Midbody



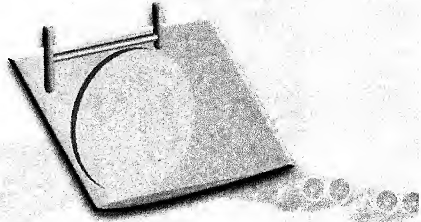
- MATL - Aluminum
- Process - Casting

Inserted Components

Folding Lugs
Machined Steel



Horizontal Fins (2)
Glass Fiber Filled Ultem
With Root Insert



Vertical Fin
Glass/Epoxy Skins and Foam Core
With Antenna and Root Insert

Air Vehicle

- Preferred Concept Design
- Preferred Concept Performance
- Manufacturing Approach
- Risk Mitigation

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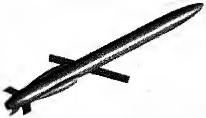
Air Vehicle Risk Items

- 1E: Design May Not Be Flexible Enough to Meet Requirement Creep
- 1F: Design May Not Be Flexible Enough to Incorporate the Jammer Requirement

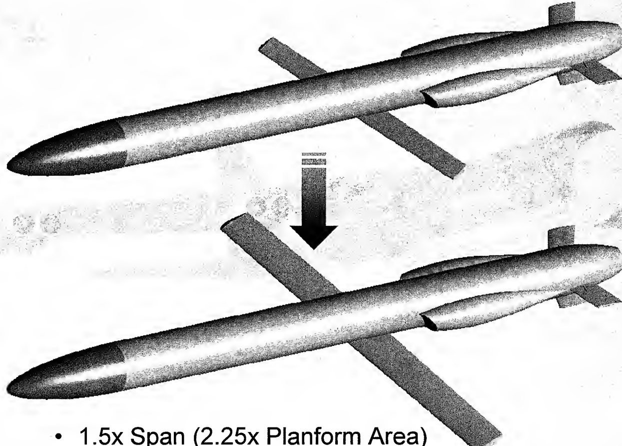
Spiral Growth Options

- Growth Volume Behind Nose
  - 235 in^3 (Excluding Start-up Battery*)
- Enlarge Wing
  - At Least 2x Current Planform Area
- Electric Wing Actuator
  - Continuously Vary Sweep Angle to Optimize for Endurance

* >50 in^3 Available Between Inlet Ducts to Relocate Start-up Battery (19 in^3)



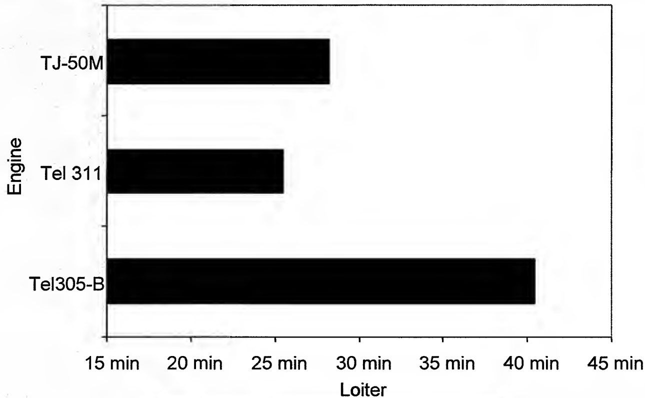
Enlarged Wing



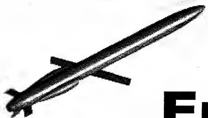
- 1.5x Span (2.25x Planform Area)
- Increases Low Speed Loiter Endurance
- Decreases Maximum Operating Speed

Enlarged Wing (cont.)

Jammer Mission Performance

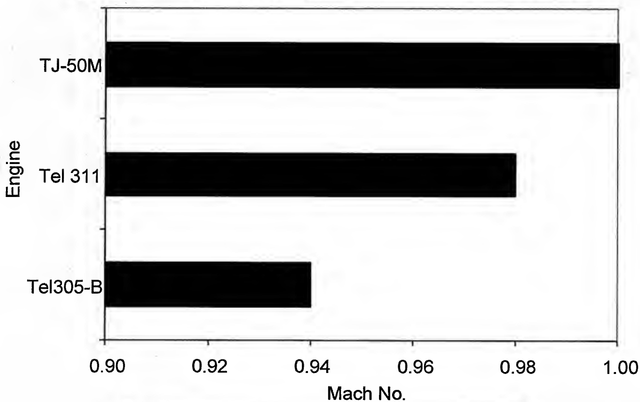


Tel305-B has enlarged wing



Enlarged Wing (cont.)

Maximum Operating Airspeed at 40,000 ft

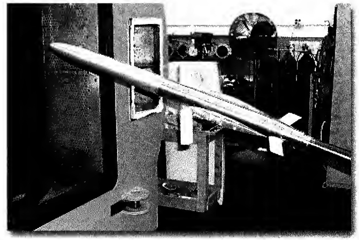


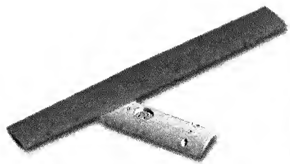
Tel305-B now operates at 40 kft

EXHIBIT 2

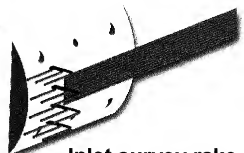
Oblique Wing Wind Tunnel Test

- Wind tunnel test of Boeing configuration
  - Boeing Polysonic Wind Tunnel (PSWT)
  - Test performed
- Goals
  - Verify transonic drag of oblique wing configuration at varying sweep angles
  - Measure longitudinal and lateral stability
  - Measure flowfield interaction between oblique wing and inlets





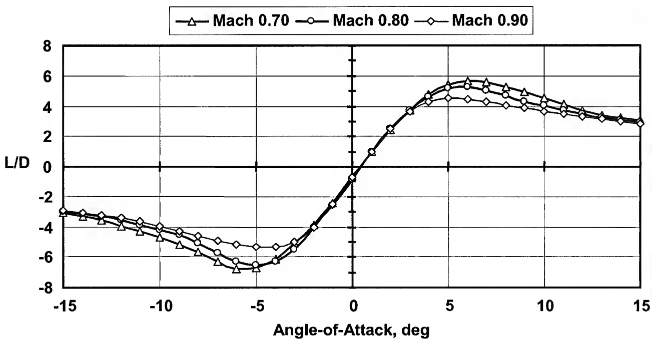
Moveable wing



Inlet survey rake

Wind Tunnel Test Outcome

- Drag is close to CFD predictions
- Stability data indicates need to increase fin area 20-25%
- Wind tunnel data used for current performance estimates



Wind Tunnel Test Outcome (Cont)

- Data confirms lower transonic drag than conventional symmetrically swept wing
- Inlet data will be used to design inlet face and boundary layer diverter